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THE OUTLOOK IN CHEMISTRY IN THE UNITED STATES[1]

IT is the highest privilege of the president of the American Chemical Society to express to you, citizens of Boston, the society's deep appreciation of your interest in our science and of your courtesy in providing entertainment for our numerous membership. In token of the reality of this appreciation, no less than in recognition of the honor bestowed upon me by you, my fellow members in the society, it is my pleasant duty to address you on some subject which might interest you as an important phase of chemistry or which might bring home to you as thoughtful citizens of this great country of ours some of the important functions which our science may be expected to fulfil in the life of the nation. It is the president's happy privilege also to select his own subject. In normal times, I confess, I should have enjoyed the pleasure the scientific man finds in riding his own hobby before a large and friendly public and I should have been tempted to try to present to you some phase of those wonderfully intricate worlds of atoms and molecules and of the forces controlling them, on which the peculiar power of our science rests. But the spirit of complete preoccupation in the great test to which our country is being put, which I know pervades the minds and souls of all of you, has led me rather to the choice of a subject of more immediate relation to our present situation. I have thought you might be interested in a discussion of the outlook in

[1] President's address delivered before the American Chemical Society, September 12, 1917, at Boston.

chemistry in the United States, with special reference to the resources of chemistry in the nation's service in war and in peace, as seen from the point of view both of chemical industry and of universities and colleges, the sources from which our chemists and our chemical lore are derived.

The great European war and now our own entry into the world struggle of free democracies against the organized military power of the last strongholds of feudal privilege in western civilization have brought home to the public as never before in the history of the world the vital place which chemistry occupies in the life of nations. What is it, indeed, that is so fundamental in this science that a country's very existence in times of great emergencies and its prosperity at any time may depend on its master minds in chemistry? It is the fact, summed up in the fewest possible words, that *chemistry is the science of the transformation of matter.* Since every phase of our existence is bound up with matter, from our birth to our return to dust, we find at every turn in life that chemistry is in demand to aid man in his effort to assure to himself a safe, scientific control in the supplying of his own needs, where nature, from time immemorial, has shown the same impersonal indifference as to his wants, his survival or destruction, that she has for every other form of life! From the transformation of our raw ores into finished metals of almost any conceivable quality and application, to the transformation of rocks and salts and the gases of our atmosphere into nourishing foods, from the transformation of the yield of our peaceful cotton fields and rich coal deposits into death-dealing explosives, to the preparation of blessed life-saving medicaments from the same crude sources—to mention only a few instances of the transformation of matter that I have in mind—it is chemistry that is giving us the power to satisfy our needs, whether it be for wise and beneficent purposes or for the fulfilment of our more baneful desires.

The crisis of the war has put this great controlling science, as it has put all other human agencies, to the fire test in every great country on the face of the earth. Acknowledgedly, chemistry has thus far staved off defeat for Germany after Joffre on the Marne had killed her hopes for a swift, crushing victory through the violation of Belgium, and had taught her that she must face a long struggle, in which, cut off from the world's supplies, she must make shift with what her own territories could yield and her chemists could produce. In the wonderful organization of power in France and in England in the midst of war, the French and English chemists have stepped in and brought their supplies of munitions of every variety, of remedies, of their new weapons of defense and offense in poison gas and liquid fire warfare up to the point of meeting now on more than equal terms an enemy prepared years in advance. And in our country too our chemists have stood the ordeal of an unprecedented time. I have in mind our splendid achievement of having solved in these three years of warfare such tremendous problems which these years have brought to us as were involved in the speeding up of the production of thousands and thousands of tons of fundamental chemical products needed by our allies and now for our own purposes—steel and iron alloys of every variety of toughness, hardness or elasticity, purified copper by the millions of pounds, aluminium for airships and motor cars, abrasives on which the trueness of every great and every small gun depends, sulphuric acid and alcohol for the preparation of explosives—foods, oils and scores of other essential products prepared on a scale never seen before—I think we may say with justifiable pride that our

great basic chemical industries have successfully risen to the demands of a situation unparalleled in its scope and urgency. There have been times of delay and times of worry, but the few failures have been due rather to financial difficulties than to a breakdown in scientific efficiency. To those of us who know that the chemist is the final controlling mind, guiding in safety for the financier these vast undertakings and expansions, the record of these years is truly a wonderfully satisfactory response to the first crucial test of the efficiency of chemistry in America.

And this result justifies the faith that we will win out just as surely in the hundreds of newer problems brought to us by our own participation in the war. Some of these problems have been brought to the attention of our members by the chairman of the two chief chemistry committees, which are cooperating with the government—Dr. W. H. Nichols, chairman of the committee on chemistry of the National Defense Council, an industrial committee, and by Dr. M. T. Bogert, chairman of the chemistry committee of the National Research Council, a research committee. From San Francisco to Boston, from Minnesota to Texas, our chemists have shown the all-pervading desire to bring to the immediate practical assistance of our country every ounce of our strength and every grain of our intelligence, and have stepped into line for service not only with splendid enthusiasm, but still better, with the grim determination of purposeful men, who know well our enemies' strength, but who will do our share to eliminate, effectively, unscrupulous militarism from the politics of the world! The immediate response to the tender of the services of our membership to the President of the United States and of the organization of the members for such service through a census of chemists has been an increase in our membership from a total of some 8,000 to 10,500, an unprecedented growth, which shows unequivocally that the chemists of the United States are of one mind in ranging themselves on the side of organized, whole-hearted and forceful support of our government in this war! Indeed, one of our chief difficulties has been to restrain our men in their eagerness until proper organization would enable the central committees to designate to each man the field in which he could serve best. To the impatient chemists, waiting for their "marching orders" it may have appeared that invaluable time has been wasted and that progress even now is all too slow. But work on all the most important problems really was quickly organized and already important results are available. As an illustration of this fact we have the brilliant and speedy success of Dr. Day and his collaborators in producing optical glass, so much needed for range-finders, which will bring our shots home to the enemy.

The very nature of most of the problems makes it impossible to name them here, but I may say that improvements in explosives, multiplication of the sources of supply from which to manufacture explosives, including the utilization of the atmospheric nitrogen for the production of nitric acid, providing protection for our soldiers and sailors against poisonous gases, the making of chemicals for which we have hitherto been dependent on importations, these are some of the problems on which many of our ablest chemists have been working with all the power and concentration that the occasion demands. I may be more explicit in regard to the problem of the home manufacture of so-called synthetic remedies, for the supplies of which up to the present time we have turned to our present enemies. We need large supplies of salvarsan for our hospitals and for our armies, we need local anesthetics, substitutes for cocaine, for our surgeons,

we need safe hypnotics to insure blessed sleep to sufferers in home or hospital, we need a long list of products to relieve the numberless ailments to which man is subject. Many of the best of these products are protected by patents, but the Adamson law will make it possible for American manufacturers to prepare these remedies in this country. There is nothing wonderful about their preparation—the scientific skill and experience of American chemists is coping with them as easily as an expert chess-player solves his problem in chess—and indeed with much the same kind of enjoyment. For instance, the obstacles in the way of the preparation of some drugs, most needed but prepared with considerable difficulty, such as salvarsan and atophan, have already been overcome in a way that leaves no doubt, if any ever existed, as to our ability to stand on our own feet, once Congress has removed the legal disabilities. University men and industrial firms have united in the vigorous attack on this problem.

This question brings me to another phase of my subject. Looking beyond the immediate future to the years ahead, why should we ever again be dependent on any foreign country for such fundamental needs of a nation as the best remedies for its stricken people—or, enlarging the question—for such fundamental industrial needs as dyes and dozens of finer chemicals, the need of which has seriously handicapped manufacturers and to a certain extent is still interfering with normal activity? It has been publicly urged in Germany—I am quoting from an excellent article by our friend Dr. Baekeland—that German dye manufacturers after the war should allow only a limited and conditional quantity of dyes to go to foreign countries, including the United States, in order to give her home industries a great lead in recovering the commerce of the world in textiles. Even if this suggestion should not be put into effect, for Germany has more to lose than to gain by a policy of trade-war after the reestablishment of peace, we may be sure that her own manufacturers will get the best of her supplies and every possible advantage. Our textile manufacturers and many other branches of industry will be at the mercy of competitors, assisted by government direction, unless we have a declaration of chemical independence in this country! Every thoughtful chemist, I am convinced, and I trust that every other thoughtful citizen, will acquiesce in the policy that henceforth in our *basic* needs, at least, we be independent of the friendship or enmity of foreign nations! And that conclusion brings me to one of the most important points in my discussion this evening: What are some of the main conditions, from a chemist's point of view, that must be fufilled, if we are to look forward to successful industrial and scientific development and independence, when the tremendous competition of peace must be met. These conditions are to be sought not only in the field of applied chemistry—and applied chemistry includes every great national industry, from agriculture to the manufacture of steel—but they involve also our universities, technical schools and colleges, the great sources from which our chemists come, not only equipped technically for their work, but carrying also the inspiration, the orientation, which will make or mar them and with them will make or mar that part of the nation's life which will be dependent on chemistry.

Turning first to the field of applied chemistry, I would like to emphasize that in my opinion the most important single factor which would lead to a tremendous increase in power in our industrial development is not immediately a question of

scientific achievement, but a factor found in a simple psychological analysis of our industrial situation. Let our manufacturers but awaken to the great significance, to the full meaning of the simple old behest that the laborer is worthy of his hire, and they will be astounded at the results. American manufacturers at present on the whole do not treat their chemists, and especially their research and directing chemists, fairly. The tendency is to exploit the chemist as an employee, instead of treating him as a partner, who brings scientific experience, skill and acumen to the aid of capital and commercial experience and standing. Manufacturers are willing to cooperate essentially on the footing of partners with great lawyers, who solve their legal difficulties—usually a wholly sterile performance as far as the welfare of the nation as a whole is concerned—but they have not yet learned to cooperate in the same fashion with men of our profession, who solve their technical difficulties to the direct enhancement of the nation's wealth and welfare! Our chemists know and feel that they are being exploited and in conscious or unconscious resentment, after one bitter disappointment or the other in their employers' fairness, they lose their fresh enthusiasm and their capacity for the whole-hearted, unstinting effort that goes with the work in which the heart and soul support the mind! All this is wrong. Research and managing chemists should be sure that success means partnership in the fruits of their success, that success will yield immediately and not in some hazy future of a soon-forgotten promise, an equitable share in the actual benefits of the work done. This is one of the real but unrecognized sources of the unquestioned leadership of Germany in fields chemical: Dr. Bernthsen, director of the Badische Anilin-Fabrik, probably the greatest of the many great German firms, told me some fifteen years ago that from the lowliest workman up to the highest chemist in his employ, every individual is guaranteed by contract a royalty, a definite share in the money earned or saved by any suggestion or discovery on the part of the individual. Contrast this wise policy with what is common knowledge concerning the situation in the great majority of American plants. Any chemist can multiply indefinitely the single specific illustration of this attitude that I will give. One of our doctors of philosophy of the University of Chicago, as chief chemist for one of the very largest manufacturing concerns in the country—a unit in a "trust"—perfected a device, simple in itself, that saved the corporation perhaps $80,000 a year: his reward was a princely increase of $200 or $300 a year in salary! Incidentally, let me say that I promptly took him away from this corporation—we can not afford to waste good men in such places. In case after case that has come to my notice from some of our leading men, chemists have been cuddled and patronized until their improvements have been completed and then recognition has come munificently in the form of a few hundred dollars a year and—oblivion. These men, leading men, let me remind you, have acknowledged to me that this treatment killed outright all the fire of enthusiasm with which they had been wont to work! There are a few noteworthy exceptions among corporations, but their strength and prosperity confirm the validity of the appeal I am making, for they have recognized that in large measure their continued prosperity has been the result of the brain-work of their chemists, cooperating with the brain-work of their directors and the capital of their corporations. There are also prominent exceptions among individual chemists: we have men in our So-

ciety who have worked their way to positions and incomes on a par with those of successful lawyers and physicians—but manufacturers should heed well that almost invariably these are men who withdrew from their original direct employment by corporations and have developed their own independent establishments, either as consulting chemists or as independent, competing manufacturers! How much wiser it would have been for the manufacturers —I am not saying, for the chemists—if these brilliant, forceful men had been kept in their establishments, as they would have been abroad, by fair treatment as partners in success as well as in effort.

I have dwelt long on this plea because I consider this message to our manufacturers from an outside observer, a university man without any industrial affiliations, to be perhaps the most important service I can try to render our country in this privileged address. Let me summarize my point with the aid of an analogy which I owe to my friend Dr. Eisenschiml's remarks after a presentation of this subject to our local section in Chicago: Just as Napoleon let every soldier feel that he carried a marshal's baton in his knapsack and thus secured the enthusiastic and self-sacrificing support of his hundreds of thousands, so our manufacturers should let their chemists feel that each one carries in his brains a contract of partnership—and all that is involved therein! If this is done, we will witness through the tremendous power of the combination of psychological momentum and trained, scientific minds, the dawn of an era of power and prosperity in our industries, in which no one need fear the after-the-war competition for which all Europe is now preparing. Enlightened self-interest is slowly revolutionizing and improving our whole social fabric by a fairer, more honest conception of the relation of capital to workers—with harm to no one, least of all, and to their own surprise, to those who have blindly been opposing the movement. And my plea for fairer treatment of productive chemists is the point at which the great world movement touches our scientific body.

Another vitally important factor in the outlook for chemistry in the United States is the adoption by our legislative bodies of a definite national policy looking toward the establishment of that independence of our country in the matter of chemical supplies to which reference was made before. Action in this direction has been happily inaugurated in the fundamental matter of the fixation of atmospheric nitrogen for the manufacture of explosives in war times, of fertilizers in peace and war. The fixation of nitrogen plants in Germany have unquestionably saved her thus far both from a military collapse and from starvation. As has been indicated before, it is important too that we become independent in as large a measure as possible also in regard to all manufactured chemicals and particularly also the finer organic chemicals, including the dyes and the synthetic drugs. The most important measure necessary to this end is protection by duties such as a non-partisan commission of experts may find necessary. American textile manufacturers, who have opposed this action in the past as far as dyes are concerned, have, I trust, learned their lesson, and will not, I hope, need a second more sharply pointed one. And other manufacturers, having found their supplies of needed chemicals cut off or enormously increased in cost, will also, I imagine, favor the establishment of conditions making home production possible. It is a source of gratification to me to state that the United States Tariff Commission, which is making a scientific study of the vexed tariff problem, most

courteously asked for, and received, the co-operation of this society in the choice of an unprejudiced expert on the chemical schedules.

Wise patent legislation is another fundamental consideration in a declaration of chemical independence. The public—that is, their representatives in Washington—should understand what is obvious to any professional student of the problem, namely, that independence is altogether a question of capital, not of science—of dollars, not of chemists. Our unqualified success in every line of applied chemistry in which investment of capital has been an attractive proposition is positive evidence that we have the chemists and the knowledge to achieve this independence, if wise legislation by tariff and patent laws will insure to capital a return sufficiently attractive and stable to have it enter these needed fields.

To illustrate concretely what this policy would mean for the nation let us consider the following: Much more than a question of coloring materials is concerned in a conscious policy to have our dye industries established on a permanent basis. It has often been emphasized that the manufacture of dyes is so closely related to the preparation of explosives that a flourishing dye industry in times of peace means ample facilities for explosives in times of war. No American would care to contemplate what our position would be in the matter of large scale production of explosives if we had become engaged in a struggle with a first class power without the benefit of the great expansion in our dye and explosives factories which our commerce with England and France brought about after 1914! When peace comes, let no American forget this lesson! One way of insuring ourselves against a lack of facilities for a sudden expansion in the production of explosives is to keep capital invested in dye factories.

Independence in the preparation of medicinal remedies, especially also of the finer modern products which we call synthetic drugs, should be as conscious an aim of the United States as independence in the manufacture of dyes. It is worth noting that the two aims support each other, for nearly all of the basic products needed for the large scale preparation of synthetic remedies are either prepared in aniline dye factories as intermediate steps toward the dyes or are so closely related to such compounds that it would be a mere detail to include these products in the normal output of a dye factory. As an instance pointing in this direction, recent correspondence with a prominent American firm, which has invented and is manufacturing what promises to be a valuable substitute for cocaine in producing local anesthesia, brought out the fact that the chief difficulty in the way of the production of the drug on the large scale which the situation demands, lies in the securing of sufficient quantities of the chemicals diethylaniline and cinnamic acid. Now, the former could and should be manufactured in dye factories with the greatest of ease, side by side with dimethylaniline, which is a common intermediate in the manufacture of many dyes, and cinnamic acid could be prepared from benzaldehyde, another intermediate. Furthermore, large research departments in well-organized dye factories will be centers of research in applied organic chemistry and practically all of our valuable synthetic drugs are such organic compounds. Indeed, it will be a matter of time only—and I should like to see that time shortened as much as possible—when some of our best equipped and most progressive dye factories will turn to the problem of these remedies as a question of the economic utilization of their equipment.

That has been the history abroad and it will be the same here. In fact, together with our long-established great pharmaceutical houses, they should find even richer, unexploited fields of effort in the problems of synthetic drugs than in those of dyes. Without question the average man spends on necessary drugs for his family at least a thousandfold the value of the dyes in the wardrobes of his whole family—the ladies, of course, included. The twitchings of rheumatism or gout, sleepless nights or a cantankerous cold are most urgent and persuasive drawers on a family purse. My professional friends in the audience know well how the modern dye industry has been built up on an accurate scientific knowledge of the connection between color and what we call the structure of the molecules, those minute worlds on the knowledge of which our power to reconstruct matter rests. We know too that the dye industry has reached, or almost reached, its full maturity and capacity. But we are only on the threshold of exactly the same kind of development in the discovery of improved remedies for curing human ills because the connection between the structure of our molecular worlds and their medicinal effect is just beginning to be systematically elaborated. Great industrial establishments founded on organic chemistry, like the dye manufacturing and the great pharmaceutical houses, collaborating with research laboratories in universities and in medical institutes, would hold out to this country the promise of a share in realizing a duplication of the conquest of the world of color, which has occurred in the last fifty years, by the greater conquest of the world of scientific medicine! A brilliant beginning has been made in this campaign by the preparation of excellent substitutes for cocaine, less toxic than cocaine itself—by the elaboration of salvarsan, by the isolation in our own country, and the artificial production, of adrenalin, a vital regulating principle produced by an organ, the suprarenal capsule, in our bodies. The isolation and exhaustive study by Kendall of the active principle of the thyroid gland, which no doubt will be followed by its artificial preparation, is a second brilliant instance of American success in this great field! When we consider the countless number of animal preparations—gland extracts, serums and antitoxins—the pure active principles of which are all we really want, but which are injected into us or fed to us, with an extraordinary amount of unnecessary and often harmful animal matter, we can realize what a boon to humanity this line of effort really means. Let me emphasize again, it is chiefly a matter of wise and foresighted legislation to make our independence and perhaps our leadership in this great field possible—we have proved that we have the scientific ability—it is a question only of putting this work on the basis of an established industry!

There are other important considerations bearing on the outlook for chemistry in the United States from the point of view of industrial chemistry—such as a law making possible commercial agreements and divisions of labor among competing houses, which exist abroad—but I must neglect no longer to turn to the third important theme embraced in my subject, the outlook for chemistry from the point of view of our universities and colleges, in which I will include the outlook for the development of the theory of our science in this country.

One can not well overestimate the importance of the standing of chemistry in our universities and colleges: they are not only the main sources of supply of chemists in the United States, but they are also the fountain-heads for the knowledge which keeps us in touch with the progress of chemistry the world over and which makes available for rapid absorption in any field

of pure or applied chemistry new discoveries, new methods of attack, new, clarifying points of view. Let me remind you that applied chemistry includes not only industrial chemistry, but also fundamental and most promising fields of effort in other major sciences. Botany through the inspiration of Liebig was probably the first of our sister sciences to apply chemistry to the solution of many of its problems. Physiology followed and now we see even zoology awakening under the stimulus of chemistry from its long morphological trance to a live science of animal life. In fulfilment of the promise contained in the life of our great fellow-chemist Pasteur, chemistry is now at last guiding not only the physiologists, but also the bacteriologists, pathologists and laboratory clinicians toward the raising of medicine from the uncertain realm of art to the safer one of science. All life is indeed but a transformation of matter in its loftiest phase and the world is at last realizing that the fundamental science of the transformation of matter holds the key which should unlock the secrets of all aspects of life, of birth, health, disease and death, and probably even of such subtler manifestations as heredity and character.

I have outlined some of these far reaching applications of chemistry in order to emphasize the fact that if we are to meet all of these demands on chemistry, if the outlook not for chemistry alone, but for all of these lines of human progress which are dependent on our science is to be one of sure promise in the United States, it behooves our people to see that the departments of chemistry in our universities and colleges be kept not only prolific as to the output of men—the vast expansion in laboratories and attendance bears witness to quantity being insured if the war does not affect us too severely—but that they also be maintained on such a high level of scientific quality that the product will consist of the very best type of men! We have received from the period from which we are now passing a magnificent heritage of world standing and ideals in our university life. The last twenty-five years witnessed an era of expansion of our resources for research and instruction, of the raising of standards of scholarship and productivity of such moment that many years before the war began the migration of our students, especially also of our chemistry students, to Europe for the pursuit of graduate work and the securing of the highest type of professional training had practically ceased. It has no longer been a question of Berlin or Munich, of Goettingen or Heidelberg; for the prospective chemistry student it has been a choice of Harvard or John Hopkins, of Chicago or Columbia, of Illinois or California, the Massachusetts Institute of Technology or Cornell—I could extend the list much longer, but fear it would tire you. And it has been so because our young men have felt that they could secure just as thorough an education here as there, just as inspiring guidance from men whose research had made them masters in their own fields. Our Remsens and Michaels, our Richardses and Nefs, our Noyeses and Gombergs, Lewises and Morses—to mention only a few of our leaders of this period—founded that independence in university education in chemistry which our country has the right to demand that we maintain.

Now, thoughtful men in our society, looking ahead, see that this great uplift in our scientific life is facing dangers which unless they are met frankly and effectively, will bring on a period of depression which will be a grave menace to all the varied fundamental interests in the life of the nation that depend on chemistry.

The first and greatest of these menacing developments has its root in the recent unprecedented demand of our industries on

our schools for research men. From university after university, from college after college, the combined lure of great research opportunities and of much larger financial returns has taken from our academic life far too many of our most promising young men, the very men on whom the country has been depending for the filling of our great university chairs as the older men now holding them gradually will age and retire. Unless prompt measures are taken we shall witness in a few years such a dearth of first-class tried material for professorships that second-rate men will be placed where the national welfare needs the best we have, and third- and fourth-rate men will be occupying positions in which we should have young men of the highest promise in the period in which they are reaching full maturity. Indeed, it is greatly to be feared that even now we are witnessing a gradual lowering of standards. It would be futile to appeal to our industries not to call the men they need, although in the not distant future they will suffer most severely from the situation which is developing, if the present tendencies remain unchecked. The only possible source of relief lies, I believe, with the presidents and trustees of our great universities, and to these the second main plea of this privileged discussion is addressed. These authorities should recognize the fact that their institutions have now entered a period of severe competition between the industries and academic life for chemists of the highest type and greatest promise. They have already learned the only method of meeting this kind of competition successfully, for they have faced the same problem in two other professions, medicine and law: in the face of the tremendous financial attractions of the practise of either of these professions our most progressive universities have simply put their law and their medical faculties on a higher, more nearly professional scale of endowment of professorships than obtains for their other faculties. They must, it seems to me, take the same measures with their chemistry staffs: it is primarily a question whether they can be awakened to that need now or whether they will let the country suffer from their lack of foresight and let us learn from the most efficient of our teachers, bitter experience. Wise provision now would not only safeguard our present standing in a critical period of our history, but in this time when the importance of chemistry has been brought home to our young men as never before, the new attitude, properly announced, would attract a large proportion of the men of brains, talent and ambition who enter professional life, but tend to study law or medicine as holding out much greater opportunities for the satisfying of their ambitions.

Adequate compensation is important for a research man—and to his type in university and college I must restrict my remarks—it is important both from the point of view of his self-respect and also especially for the sake of comparative freedom from worry concerning a fair provision for his family. But inadequate compensation is not the only danger seriously threatening the outlook for chemistry in our universities. Let us remember that healthy progress in our science is dependent primarily on university men pursuing great lines of original investigation. It is true that we now have well-endowed national institutions of research, such as the Rockefeller Institute and the Carnegie Institution, but universities can not afford to surrender to these the main burden of insuring progress in the theory of our science, because these *are not teaching* institutions. To take from our universities the choicest of our research men would deprive our

young men of that inspiration and fertilization of their minds in the period of their greatest acceptiveness which early intimate association with great investigators alone can give. To my mind it is clear that if universities would fulfil their highest mission they must remain the seats of the best type of research. But such research is the product of an extraordinarily sensitive state of mind. Only the greatest powers of concentration of thought make it possible. The investigator is groping for truth in unexplored regions, wary of every pitfall, most fearful indeed of possible illusions of his own highly excited imagination. Let any one imagine himself groping in a dark and unfamiliar room and he will easily realize that the undisturbed concentration of his every faculty is the only way for him to attain his goal! Let the rush of an automobile or the screech of a locomotive detract his attention but for an instant and he may well have to rue a stubbed toe or a grazed shin! Now, figuratively speaking, there are too many noisy automobiles and screeching locomotives in the lives of our distracted investigators. American universities, in general, have the unfortunate custom of loading down their best investigators as heads of departments with administrative duties of all varieties, ranging from clerical functions to committee work, important for the institution, but always a grave obstacle in the path of successful research. Younger men, even when they show marked research ability, are too often worn out with excessive duties of instruction and laboratory detail, when their minds need their keenest edge to cut their path to the elusive truth! Men in whom the research instinct is inborn and overpoweringly intense, will break through these difficulties—usually at the cost of the neglect of other duties—but our system is one that means an extraordinary waste of talent for the highest type of work on duties that minds of lesser fineness could do just as well or better. On top of these older defects, which we have been only slowly recognizing and removing, have come in the last few years the further distracting duties of necessary public service. Let me repeat what I stated earlier in the evening: every one of our great chemists, as well as of our less well known ones, is eager to devote every particle of his knowledge and strength to the sacred duty of the moment. Theoretical work has been set aside except as it contributes directly to the cause of national defense. But let us begin to realize now that when peace comes we must let our investigators return to the service of pure science, we must leave them severely alone, free from committee work of any kind, so that they may recover that opportunity for concentration which is needed for productive research of permanent value! Some of our research men, I dare say, are being spoiled forever for this service, exactly as many a returning soldier will have lost in a craving for adventure his fitness for ordinary civic responsibilities.

There is a strong movement too in our society to bring universities and industries into closer relations, a laudable movement with which I am in heartiest sympathy, but which can bring unmixed benefits only if it is most wisely guided. It would be fatal if it were allowed for the sake of temporary advantage to injure in any way that search for truth for the sake of the truth itself on which, after all, the great structure of our science as of all sciences rests. Let the large proportion of members in our society who are primarily interested in applied chemistry, recall as a typical illustration of a very general truth that chemists had tried for fifty years to manufacture sulphuric acid by the contact process and had utterly failed, and that success finally

came only when the laws of physical chemistry, products of the research of guileless university professors, were available and were applied to the problem! Who can doubt that we still need the efforts of new Faradays, van't Hoffs, Roozebooms, Bertholets, Kekules! The question has impressed me as so vital a one for the outlook for chemistry in this country that as president of our society I have put on the committee charged with the development of relations between industries and the universities primarily university research men, with the understanding that they will give to pure research in our universities the benefit of every doubt in their recommendations. I trust that our society, as a whole, will realize that it were better that our industries suffer somewhat temporarily than that our national strength in chemistry be crippled at the source. My personal opinion is that we can attain both of our objectives—to use a war phrase. Thus, our present war duties are making university men personally acquainted with numerous practical problems which in many cases after the war, will probably form the basic material for investigations of theoretical relations. Even if they are only in a measure as successful as those of Baeyer, when through the study of the structure and synthesis of indigo he opened up the great theoretical fields of knowledge of tautomerism, of the theory of unsaturated compounds and of cyclic derivatives, they will advance both branches of our science, applied and theoretical chemistry. Efforts along the lines of developing the theory of the connection between molecular structure and physiological or medicinal properties are now taking root in a number of our universities. But, on the whole, I would recommend that technical research problems—routine analytical and control work should be altogether barred from our universities —that technical research problems be limited in universities to picked men interested in applied chemistry and holding possibly professorships or other appointments in industrial chemistry. In time, these men will become dependent on their colleagues devoted to pure science for keeping step with the progress in our science. I would urge, too, the perhaps novel recommendation that remuneration for such work be made a departmental and not an individual affair. This wise provision is being enforced in those modern medical schools which demand research work of their staffs, fees for practise reverting to the university hospitals and not to the individual. As applied to chemistry, such a provision would be desirable, in the first place, because it would to a large extent reduce the temptation of financial inducements for the men whose talents fit them for work in pure science and whom the country needs for such work. In the second place, one will find that the university man interested in a technical problem is, after all, less useful in a teaching department than the man devoted to pure research: the pressure from outside will lead him to throw a greater mass of administrative detail, of instruction or of the care of research men, on his colleagues. The result is that the department and not the individual really carries the burden of the problem in applied chemistry—exactly as in the medical schools, which still allow their staffs to practise for their own financial benefit, this is all too often done with the drawbacks of inefficient teaching, the ignoring of administrative responsibilities and the leaving to the care of others the provisions for education in research.

I have dwelt on the details of this great problem which is confronting our society, because I would protect the outlook for the growth and success of theoretical chemistry in our country by every means in my power. We have a splendid record: we

are easily leaders in the domain of knowledge based on the exact determinations of atomic weights—a knowledge which leads among other results to habits of more exact, more critical methods in all fields of our science. Arrhenius told us that America is leading in the difficult work of the rigorous examination of the theory of ionization and of establishing it on a finished basis. The development of the field of free energy relations is more intensely cultivated, here I imagine, than in any other country. In the application of modern theories of atomic structure and of the electron theory of valence to all branches of chemistry, especially also to organic chemistry, we are, I believe, easily in the front. Our very youth, as a people, has preserved to us in science as in national sentiment, that whole-hearted enthusiasm for ideals, which in world politics has made us the most altruistic nation on the face of the earth and which in science finds its expression in the pursuit of knowledge for the sake of the pure truth alone, a pursuit characteristic of the best research in our universities and colleges!

And so let me conclude my remarks on the outlook for chemistry in America by emphasizing that we have a goodly heritage of success both in our great industries and in our great universities, which will form the safe basis of a brilliant future, if we will but approach the problems of the moment and of the immediate future in characteristically American fashion, with a spirit wisely combining altruistic principles with practical, worldly common sense. This means the "square deal" in industrial life for the product of the brains of the research chemist, combined with wise laws to insure to capital a fair and tolerably safe return for investment in chemical industries, needed to make our country chemically independent. And it means too the placing of chemistry in our universities on a plane with the other great professions, law and medicine, in order to hold in this great science, so important for the welfare of the nation, the needed numbers of men of brilliant minds and energetic ambitions —combined with the devotion on their part to the search for the truth, for the establishment of the great laws of our science, for the sake of that truth, that science, alone!

JULIUS STIEGLITZ

UNIVERSITY OF CHICAGO

SCIENTIFIC EVENTS

THE LANE MEDICAL LECTURES

THE sixteenth course of Lane Medical Lectures at Stanford University will be delivered by Simon Flexner, M.D., LL.D., director of laboratories, Rockefeller Institute for Medical Research, New York City, N. Y., on the evenings of October 8, 9, 10, 11, and 12, 1917, at 8:15 o'clock in Lane Hall, Stanford University Medical School, San Francisco, California, on "Physical basis and present status of specific serum and drug therapy."

The titles of the separate lectures are as follows:

October 8: Epidemic Meningitis; Lobar Pneumonia; Bacillary Dysentery and Specificity in Bactericidal Sera.

October 9: Gaseous Gangrene; Shiga Bacillary Dysentery; and the Principles of Homoserum Therapy.

October 10: Poliomyelitis and the Principles of Homoserum Therapy.

October 11: Local Specific Therapy as illustrated by the Serum Treatment of Epidemic Meningitis, Poliomyelitis and Tetanus.

October 12: Chemotherapy of the Spirochetal Infections.

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

DURING the season from October, 1917, to April, 1918, inclusive, the Anthropological Society of Washington, D. C., will provide a very interesting program of papers or lec-

tures chiefly concerned with divers nations of Europe and the East now at war or likely to be involved before long, including especially some of our less known and smaller allies. The general plan of most of these monographs will be a résumé of earliest known data, racial origins, shiftings and blendings, historical development and present status, aiming to further a more thorough acquaintance with these peoples, their characteristics and capabilities and the causes which have made them what they are. The appended schedule may be subject to some changes in detail as the season advances and is now necessarily incomplete as to one or two items, but will give a sufficient idea of what is to be expected. The society meets at 4.30 P.M. in rooms 42–43 of the new building of the National Museum on alternate Tuesdays, beginning October 2d, 1917.

PROGRAM

October 2. Dr. Aleš Hrdlička, Bohemia and the Bohemians.

October 16. Dr. Mitchell Carroll, The Story of Greece.

November 6. Professor James H. Gore, Belgium.

November 20. Mr. George J. Zolnay, Roumania, Past and Present.

December 4. Dr. Amandus Johnson, Scandinavia; Mr. Juul Dieserud, Certain Customs of Norway.

December 18. France.

January 15. Dr. Voyslav M. Yovanovitch, Serbia.

January 29. Voyslav M. Yovanovitch, Italy.

February 12. Dr. Joseph Dunn, Scotland.

February 26. Dr. B. Israeli, Russia.

March 12. Mr. E. T. Williams, The Origin of China.

March 26. Mr. E. T. Williams, Holland.

April 9. Dr. Paul Haupt, Mesopotamia and Palestine.

April 22. Annual meeting and election of officers.

Some, perhaps, most, of these lectures will be illustrated by lantern slides or otherwise. The public will be welcome.

Wm. H. Babcock, *President*

EFFECTS OF THE WAR ON TECHNICAL EDUCATION

Walter Humphreys, registrar of the Massachusetts Institute of Technology, has compiled registration statistics which indicate the effects of the war on technical education. The total registration is between eighty-five and ninety per cent. of what it was last year at the same time. The freshman year shows an increase, the percentage in terms of last year's figure being 104, while the second, third and fourth years classes are respectively 93 per cent., 75 per cent. and 86 per cent., of the number in the school in June.

The graduate students stand at 60 per cent. of last year's figure. There is the most shrinkage in the juniors, the sophomores of last year, to whom two years more of schooling has perhaps seemed a long time. The return of eighty-six per cent. of the juniors to be seniors is evidence in favor of the junior summer camp. The purpose of this was to give some military practise and an opportunity to anticipate fourth-year studies, and complete work at an earlier date.

In a consideration of the effect on the courses it may be well to omit those with less than fifty men, since the defection of a few students makes an undue percentage shrinkage. One of them, however, naval architecture, is stimulated by the war, the increase being 16 per cent. The course in naval architecture has always been small in attendance and has been maintained by the institute as a contribution to education.

Of the larger courses civil engineering maintains practically the same figure as in former years, the shrinkage being 1.2 per cent., while electrical engineering opens the year with a loss of only 2 per cent. Chemical engineering has 12 per cent. increase. Engineering administration is practically holding its own, having lost only six and one half per cent. since the last registration. Architecture has declined nearly one third in the number of its students. Perhaps the undue cost of building materials, fifty to one hundred per cent. in many cases, and the consequent gossip that building operations will be at a standstill, has had its influence in deterring young men from taking it up with

usual vigor. Mechanical engineering has lost about 21 per cent. This is a study that should be stimulated by the war. In this work Professor Miller, head of the department, has undertaken for the U. S. Shipping Board the management of the schools for marine engine-room officers in the principal ports in the country.

WORK OF THE NATIONAL RESEARCH COUNCIL

UPON recommendation of the National Research Council Dr. Augustus Trowbridge, of Princeton University, and Professor Theodore Lyman, of Harvard University, have received commissions in the Signal Corps, U. S. A., for work in sound ranging. They have sailed for France to investigate conditions at the front in this subject. The sound ranging service which will be developed under their direction will utilize in the near future more than fifty men. Captain Horatio B. Williams is in charge of the development work in this country during Major Trowbridge's absence.

A meteorological service has been organized under the Signal Corps, U. S. A., in which about one hundred physicists and engineers will be engaged in aerological observational work under the direction of Dr. William H. Blair, of the U. S. Weather Bureau, who has received a commission of major and has sailed for France to investigate conditions abroad. Forecasting work for the American Expeditionary Force in France will be in charge of Mr. E. H. Bowie, of the U. S. Weather Bureau, who has likewise received a commission of major in the Signal Corps and is already on his way to France. Major Bowie will be assisted by Mr. R. Hanson Weightman, of the U. S. Weather Bureau, who has received a commission as lieutenant in the Signal Corps.

Professor Charles E. Mendenhall, of the University of Wisconsin, has received a commission of major in the Signal Corps, U. S. A., and has been placed in charge of the development of aeronautical instruments.

All of the work of these services, sound-ranging, meteorology and aeronautical instruments, is included within the scope of the Science and Research Division of the Signal Corps, which in accordance with a recent order of the chief signal officer has been established and placed under the direction of the National Research Council, of which Major R. A. Millikan is the executive officer. The functions of this division of the Signal Corps are two-fold, namely: (1) to furnish personnel of the research sort to the other divisions when the situation warrants the assignment of men of this type to these divisions, and (2) to have a personnel of its own which maintains intimate contact with all research and development work in other divisions, and distributes research problems to university, industrial and governmental research laboratories with which it is associated. Similar, though in some cases less formal, relations have been established with other technical bureaus of the War and Navy Departments.

Upon request of the French High Commission a number of American physicists and chemists are being sent to France to assist in various war problems in which technically trained men are needed. Except in certain cases, the Interministerial Commission in Paris will assign them to work in university laboratories and in technical services of the government. Upon recommendation of the National Research Council the following men are receiving commissions in this connection and a number of them have already sailed for France:

Professor R. W. Wood, of Johns Hopkins University, major in the U. S. Signal Corps.

Messrs. Roy W. Chestnut, Leonard Loeb and Samuel Sewall, lieutenants in the U. S. Signal Corps.

Professor Edward Bartow, of the University of Illinois, major, and Professor Reston Stevenson, of the College of the City of New York, captain in the U. S. Sanitary Corps.

Messrs. Ralph L. Brown, of the University of Chicago, George Scatchard, of Columbia University, and Kirke W. Cushing, of Western Reserve University, lieutenants in the U. S. Sanitary Corps.

SCIENTIFIC NOTES AND NEWS

THE trustees of Columbia University have dismissed Professor J. McKeen Cattell from the chair of psychology which he has held since 1891, on account of a letter which he

addressed to members of the Congress, asking them to support a measure which had been introduced against sending conscripts to fight in Europe against their will. Professor Cattell has given out a statement in which he says that he is opposed to war and to this war, but that he has engaged in no agitation against the government, and has not written anything opposing conscription or against sending an army abroad. He maintains that forcing "conscientious objectors" to fight in Europe is not only contrary to democratic principles, but also subversive of the efficiency of the army and of national unity. He claims that it is the duty as well as the constitutional right of a citizen to petition the government to enact legislation believed by him to be for the national welfare. For a university to dismiss a professor for doing this is both unjust and illegal. Under the circumstances Professor Cattell believes that it may be in the interest of SCIENCE and of the American Association for the Advancement of Science for him to retire from the editorship which he has held for twenty-two years. He has addressed a letter to the chairman of the Committee on Policy of the Association requesting that a successor be selected.

AT Peking the cornerstone of the hospital and medical college of the Rockefeller Foundation was laid on September 24 by Fan Yuen-Lien, minister of education. Dr. Paul Reinsch, the American minister, presided at the exercises, which were attended by Admiral Austin Knight, commander of the American Asiatic fleet. Dr. Frank Billings, chief of the American Red Cross mission to Russia, who is now in Peking, made the principal address.

PROFESSOR JOHN S. SHEARER, of the department of physics of Cornell University, has received a commission as major in the National Army. Since the declaration of war, Professor Shearer has been on duty at the Cornell University Medical College in New York City, instructing officers of the Medical Corps and the Medical Reserve Corps in roentgenology, and conducting conferences for the standardization of X-ray apparatus.

LEAVES of absence for the year 1917–18 were granted by the administration committee of Cornell University to Professor George Young, Jr., of the college of architecture, and Professor Ernest Merritt, of the department of physics, who are engaged in work for the government, to L. L. Silverman, instructor in mathematics, who is in the service of the committee of public safety of the state of Massachusetts; to Professor Samuel N. Spring, of the department of forestry, in order that he may serve as a captain in the 20th Engineer (Forestry) Regiment, and to Professor Allyn A. Young, of the department of economics, to permit him to serve as chief of war trade statistics in the Division of Export Licenses at Washington.

AT the University of North Dakota there has been established a research committee to cooperate with the National Research Council in connection with the advancement of a variety of problems of scientific and practical interest. The committee consists of Dr. Earle J. Babcock, chairman, dean of the engineering colleges and professor of industrial chemistry; Dr. J. M. Gillette, professor of sociology; Dr. George A. Abbott, professor of chemistry; Dr. A. G. Leonard, professor of geology, and Dr. Charles E. King, professor of physiology.

J. W. BAILEY has resigned an assistant professorship in zoology at the Agricultural College of Mississippi to undertake research work for the U. S. Department of Agriculture, with headquarters at Tempe, Arizona.

DR. MINNIE A. GRAHAM has resigned her position as instructor in analytical chemistry at Wellesley College to act as abstracter for the research department of the General Chemical Company in New York.

DR. HERBERT C. MOFFITT, dean of the University of California Medical School, has been called into active service as a major in the Medical Officers' Reserve Corps, and is stationed at the Army Hospital at San Antonio, Texas.

DR. W. A. PERLZWEIG, assistant professor in biochemistry in the Creighton University College of Medicine, has been appointed first lieutenant in the Sanitary Corps of the army.

AT the opening exercises of Columbia University, Dr. Cassius J. Keyser, of Columbia University, gave the address, the subject of which was "The enterprise of democracy." The address of the College of Physicians and Surgeons was given by Dr. Hans Zinsser, professor of bacteriology, his subject being "Medicine, the great opportunity."

SENOR AUGUSTO VILLANUEVA, Santiago de Chile, has become a member of the Ramsay Memorial Committee for Chile.

EDWARD BOOTH, assistant professor of chemistry in the University of California, died at his home in Berkeley on August 23.

LIEUTENANT-COLONEL T. H. BOARDMAN, who had charge of the work in physics at Christ's Hospital, London, died of wounds on August 4 while on active service in the army.

DR. J. R. TOSH, lately assistant professor of zoology in St. Andrews University, has died in Mesoptamia from "heat stroke."

As already announced, the thirty-second general meeting of the American Electrochemical Society is being held in Pittsburgh from October 3 to 6. *The Metallurgical and Chemical Engineering* states that a special feature of the meeting will be a series of papers and discussions on electrochemical war supplies, and the part the electrochemical industry will play in the present struggle. The committee in charge is outlining an elaborate program of technical sessions, visits to industrial plants and entertainment features. It invites the delegates to arrive in Pittsburgh on Wednesday, October 2, so as to meet informally and enjoy some recreations which have been planned for them. On Thursday, October 3, a regular meeting of the society will be held in the morning, with optional excursions to industrial plants in the afternoon. In the evening an illustrated lecture on a semi-technical subject will be given. On Friday, October 4, a symposium on electrochemical war supplies will be held in the morning, followed by excursions to industrial plants in the afternoon. A subscription dinner will be held at the William Penn Hotel in the evening. Saturday, October 5, will be devoted to an all-day excursion, on a special train with complimentary luncheon, to several industrial plants in the Pittsburgh district."

ACCORDING to the London correspondent of the *Journal* of the American Medical Association official statistics show that on an average there has been an increase in food prices of 104 per cent. compared with July, 1914, the month before the war began. The increase varies from 65 per cent. in the case of fresh butter to 191 per cent. in the case of certain parts of frozen mutton. The average price of bread—23 cents for the 4-pound loaf—is double that in July, 1914, and flour shows a proportionately greater advance, amounting to 109 per cent. The price of granulated sugar had risen over the war period from an average of about 4 cents to nearly 12 cents per pound, but increased duty accounts for about 2.5 cents of the rise. The average price of cheese is slightly more than double than in July, 1914; that of eggs, slightly less than double. The price of tea is 74 per cent. higher, but about half of the advance is due to increased taxation. Butter and margarin show increases approximating to 65 and 74 per cent., respectively, over pre-war prices. Milk prices had risen 60 per cent., or 4 cents per quart. In arriving at the general percentage increase, the several articles are weighted in accordance with the proportionate expenditure on them in pre-war family budgets, no allowance being made for the economies resulting from changes in dietary which have been effected since the beginning of the war, especially in those families in which the total income has not been increased by advances in rates of wages, greater regularity of employment, increased output, or the working of overtime. As an illustration of possible economies in this direction, if eggs are omitted from the dietary, margarin substituted for butter, and the consumption of sugar and fish reduced to one half of that prevailing before the war, the general percentage increase since July, 1914, instead of being 104, would be 72. During last month alone the general level of retail prices of the principal articles of food rose about 1 per cent. The prices of British beef increased

about 5 per cent., and those of other meat from 3 to 4 per cent. Bacon and fish showed some decline in price as compared with a month ago.

In connection with work in food conservation the railway freight claim agents in Texas are opening the way for cooperation with other agencies interested in food production. On Saturday, August 4, representatives of three of the important railways in Texas met in conference with Dr. J. J. Taubenhaus, of the Texas Experiment Station, and Dr. F. H. Blodgett, of the Agricultural Extension Service, to discuss methods by which losses in transit may be reduced in shipments of perishable farm products. The matter was discussed both from the point of view of the claim agent in reducing the financial expenditure in settling damage claims on the part of the shippers and others, and from the point of view of food conservation, since the damaged products, for which claims may be filed and paid, draw from the food supply of the country with no benefits to any one since even damage claims only partially represent the true value of the products concerned. Plans were outlined for the investigation of the unknown factors involved by the pathologist of the Experiment Station, and for the cooperation between the Extension Service and the railway agricultural agencies to disseminate information in regard to the different modes of handling produce to eliminate losses through shifting of cargo and other causes which are already well understood but not always carefully practised.

It is stated in the *Boston Medical and Surgical Journal* that the thirty-two new hospitals which are being built by the medical corps of the army for the care of the National Guard and National Army camps will cost about $14,500,000. The aim of the medical department is to have hospital provision for 5 per cent. of the enlisted force by fall, and then extend it to 10 per cent. Abroad, facilities for 20 per cent. of the American expeditionary forces will be available. Provision will be made at the cantonments in this country for 3 per cent. of the troops in each camp. Each hospital with the space reserved for extensions will require sixty acres. The buildings will be 24 feet wide, the length varying to meet the needs. A ward about 157 feet long will accommodate 32 beds. A cantonment hospital on a basis of 1,000 beds will include about 70 buildings, if each ward is considered as a building. Adequate laboratory facilities will also be provided, and plans are being made to appoint permanently to the staffs of the hospitals, men especially trained to do laboratory work in order that careful tests may be made of each and every soldier for tuberculosis, intestinal infections, and all other infectious diseases.

In Kansas a deep well struck rock salt at 690 feet below the surface and penetrated 600 feet of rock salt in beds from 5 to 60 feet thick, according to the United States Geological Survey. A large area in this state is underlain by salt, which is mined by many shafts and obtained by pumping brine. Drilling for oil in Texas and Louisiana has revealed the presence of tremendously thick deposits of rock salt at a depth of a few hundred feet. Thicknesses of 2,000 feet are common, and one drill hole passed through more than 3,000 feet of rock salt. Most of the salt made in Utah is produced by evaporating the waters of Great Salt Lake, and in California by evaporating sea water. These sources are inexhaustible, and the limit of production by solar evaporation will therefore never be reached.

The Electrical World states that for several years past from fifteen to thirty engineering teachers have spent part of the summer vacation at the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company in getting acquainted not only with the apparatus manufactured by this company, but also with its engineering designers, commercial engineers and works executives. This year there were twenty-four men from seventeen different states and from Canada and Japan, representing twenty-three different engineering schools. Most of their time is spent on actual work, either on assembly or test floor or in the engineering offices, but part of the time is given up to a series of meetings, which include inspection and discussion of apparatus being manufactured, talks on engi-

neering opportunities and requirements, discussions of teaching problems, excursions to other plants and social meetings. This course gives engineering teachers an opportunity to become acquainted with the latest developments in electrical power apparatus, with shop methods in use in large manufacturing concerns, and to meet and exchange ideas on teaching subjects with other engineering teachers of experience. Since the Westinghouse company draws men from engineering schools, it is of advantage to it that students may know not only of the opportunities open but of methods of working efficiently in its organization.

UNIVERSITY AND EDUCATIONAL NEWS

DR. JOHN R. MURLIN, for eight years assistant professor of physiology in the medical school of Cornell University, has been appointed director of the new department of vital economics at the University of Rochester. This department is being organized from funds made available by the will of Lewis P. Ross, whose will gave to the university the residuary estate of more than $800,000, the income only to be used "to the end that human life may be prolonged with increased health and happiness." The trustees were instructed to expend that income for two purposes—to contribute toward the support, improvement, and extension of the department of household economics of the Mechanics' Institute of Rochester, and to establish in the university a department of vital economics. Dr. Murlin is now a major in the Sanitary Corps of the national army, and head of the food division in the surgeon general's office.

THE school of engineering of the Pennsylvania State College has the largest freshman enrollment in its history, numbering 271 as compared to 210 at this time last year. The upper classes are from 50 to 75 per cent. of normal, due to the large number who volunteered last spring.

PROFESSOR GEORGE H. PERKINS, dean of the College of Arts and Sciences of the University of Vermont and professor of natural history, has been designated as acting president for the next year. President Guy Potter Benton has been granted a year's leave of absence by the trustees in order to comply with the request of the National War Work Council to aid in the coordination and direction of the council's work in Europe. President Benton sailed early in September in charge of a force of thirty Young Men's Christian Association men.

ALBERT RUSSELL MANN, professor of rural social organization, and acting dean has been appointed dean of the New York State College of Agriculture at Cornell University.

DR. C. P. FITCH, of the New York State Veterinary College, has been appointed professor of comparative pathology and bacteriology and chairman of the division of veterinary medicine in the department of agriculture, University of Minnesota.

THE following promotions have been made at the school of medicine, Western Reserve University: Paul J. Hanzlik, to be assistant professor of pharmacology; Cyrus Hartwell Fiske, to be assistant professor of biochemistry; Roy Wesley Scott, to be associate in physiology; Julius Moses Rogoff, to be senior instructor in experimental medicine; Roy Bartlett Metz, to be associate in ophthalmology; Joseph Edgar McClelland, to be instructor in pediatrics; Carlos Eugene Pitkin, to be instructor in diseases of the nose, ear and throat; Chester Dale Christie, to be instructor in medicine; Marion Blakenhorn, to be instructor in medicine.

PROFESSOR N. C. CURTIS, of Tulane University, has been appointed associate professor of architectural design in the University of Illinois.

DR. R. M. STRONG has been promoted from associate professor of anatomy to professor of microscopic anatomy in the medical school of Vanderbilt University.

DR. O. VAN DER STRICHT, professor of histology and embryology at Ghent, Belgium, who for the past two years has held the post of fellow in cytology in the anatomical laboratory of Western Reserve University, has been

appointed lecturer in anatomy at the Johns Hopkins University.

DISCUSSION AND CORRESPONDENCE

WHEN IS A FORCE NOT A FORCE?

In his communication to Science for March 16, 1917, Mr. A. H. Patterson very pertinently calls attention to the vagueness, lack of precision and error in the treatment of the force concept by current physics text-books. Much of Mr. Patterson's criticism deals with Newton's third law of motion and appears to be based on a misinterpretation of that law. To this I wish to call attention.

Force is always exerted by one portion of matter, A, upon a second portion of matter B. These may be distinct bodies or parts of the same body. If A exerts a force on B then, the third law tells us, B exerts an equal force in the opposite direction on A. If the force of A on B *is* called the action, the force of B on A is called the reaction. The action and reaction do not act on the same body or body-part. Failure to fully appreciate this seems to be responsible for the present as well as many other misinterpretations of the third law.

Mr. Patterson asks: "What is a student to think when he is told that to *every* action there is *always* an equal and contrary action, and is then informed that (only) an unbalanced force acting on a mass produces acceleration?" The two statements are mutually consistent and true. In order to safeguard the student against some of the pitfalls which are dangerous even to his teachers it is only necessary to make the information more complete.

Mr. Patterson's problems may well serve this purpose. The ball at the end of a rubber band is the first of these. Let us ignore the effect of gravity. When the ball is whirled about in a circular path at uniform speed the pull exerted by the rubber band *on the ball* is called the centripetal force. No other balanced force and gives rise to an acceleration which manifests itself in the change in direction of the velocity. The equal and contrary action is the outward pull of the ball *on the string*, known as the centrifugal force. The string is not accelerated because the pull of the support at the fixed end is equal and opposite to the centrifugal pull at the free end. The forces on the string are balanced.

A porter pushes a truck at uniform speed over level ground. Then the force which he exerts forward on the truck is equal to the backward frictional force. If this frictional resistance were suddenly to vanish, the forward force exerted on the truck by the porter would be the only horizontal force, hence unbalanced and a forward acceleration would result. Both with and without friction the truck pushes backward on the porter with an equal force. In addition to pushing forward on the truck the porter is pushing backward on the ground with his feet, and consequently the ground is pushing him forward. If the forward push of the ground and the backward push of the truck are equal the forces on the porter are balanced and he moves without acceleration. Everywhere the forces act in pairs, because there must be an exerter of the force and a body on which it is exerted. Newton's law has a meaning only when both bodies are considered.

Newton's third law requires no distinction between inertia-reactions and other forces. To introduce them serves to complicate rather than to simplify. The following problem utilizes Mr. Patterson's method, quoting freely from the closing paragraphs of his communication.

A mass M rests on a perfectly smooth horizontal surface. To M we apply a horizontal force F. Being the only horizontal force it is unbalanced. It is opposed by an inertia reaction *which can in a sense balance it, but can not hold it in equilibrium because a force opposed only by inertia reaction always produces acceleration.*

It is difficult to see the need of this devitalized form of the third law, either from the point of view of principle or of practice. Forces do always exist in pairs, yet the forces on either or both of two bodies between which force-action exists may be unbalanced.

Mr. Patterson assumes a contradiction where none exists and then proposes an artificial way out.

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THE THIRD LAW OF MOTION AND "INERTIA REACTION"

THE recent article by Mr. Andrew H. Patterson in SCIENCE for March 16, 1917, impels me to add to the discussion of questions in mechanics something that I have tried to make clear to students. It is along the line of Mr. Fulcher's article of November 24, and concerns the confusion between the third law of motion, the second law, and D'Alembert's principle.

Mr. Patterson appears to object to teaching that "to every action there is always an equal and contrary action" or that "forces always occur in pairs" and at the same time that an "unbalanced force" produces an acceleration. There is surely no inconsistency in this, since the "pairs" of forces or the action and reaction act on different bodies, say A and B, then if no other bodies are acting upon them, there will be an unbalanced force on each, and each will be accelerated, but in opposite directions. Evidently another pair of forces may act between B and C such that on the whole the forces on B exactly balance, and yet A will be left with an accelerated motion. On the other hand, while it is clear from writing the equation representing the second law of motion in the form $F - Ma = 0$, that *if* a force equal to the mass times the acceleration *should* act on the body in the opposite direction to the impressed force, these forces would be in equilibrium, this is not a case of the third law, which specifies that the forces considered act between two bodies and not on one and the same body. If for a system one adds the idea (D'Alembert's principle?), that the internal actions and reactions of any system of bodies are in equilibrium among themselves, a special case of the third law, one obtains the more general statement that *if* forces equal to the several masses times their respective accelerations *were* applied, etc., a form which is useful in the handling of problems, but which does not imply that such forces *are* acting and does not call for the idea of "inertia reactions."

The case where "inertia reaction" is most frequently drawn in, in connection with action and reaction is the instance of an object being whirled around on the end of a string. Now when one explains the motion of the moon about the earth as due to the action of the gravitational force on the moon directed towards the earth, one looks for the "reaction" in a gravitational force on the earth directed toward the moon, but not a force on the moon, and this reaction on the earth has nothing to do with the mass $\times$ acceleration of the moon, but would be the same if the moon were at rest in the position which it has at any instant. Is not the same true for the ball and string? Consider the case where a person grasps the ball by a hook at the end of a diameter, and pulls on a cord at the other end with the force F, the ball as well as the cord is strained, and we may say that the ball is pulling on the string and the string on the ball (the third law), in virtue of this strain. Now let go at the one end, in order to continue to apply a force F the hand must be moved with the same acceleration which the ball has in order to keep the string stretched, and would not the ball in the neighborhood of the string remain strained as before and hence the forces between ball and string be of the same nature as before? Now suppose the ball swung around the head, as Mr. Patterson suggests, would not the ball still remain strained and would it not pull on the string with a force which would be exactly the same as if the ball were at rest, but in the same state of strain? If so why bring in an inertia reaction? In the illustration of the porter pushing a cart, as long as he *actually pushes* there is an equal counter force *on him*, but in the one case the push on the cart may be balanced by friction, and in the other it would be an unbalanced force on the cart. Actually if friction suddenly ceased would not the porter probably notice that the force with which he was pushing had suddenly diminished, and

that he had to hurry up to push at all? It would seem to me to be true in this case also that the push back on him would be the same if the cart were in the same state of strain and at rest.

If the point of view brought forward here is correct it would seem to me desirable to leave out of any elementary discussion of mechanics an "inertia reaction."

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AN ADDITIONAL NOTE ON "THE OOLITIC AND PISOLITIC BARITE FROM THE SARATOGA OIL FIELD, TEXAS"

About three years ago the writer wrote a description of some barite of unusual type from the Saratoga Oil Field, Texas.[1] Specimens of this mineral have been brought to the surface in pumping, and they have been found, in all cases reported to the writer, at a depth around 1,200 feet, indicating that they probably have their source in a definite geological horizon. At the time the above-mentioned paper was written it was supposed that the concretions of this mineral originated with the sands in which they were found but there was no definite information on the subject.

In discussing this matter a short time ago with Mr. E. G. Woodruff, he stated that at least some of these concretions undoubtedly formed in the wells after they were equipped, because they had been found reaching a quarter of an inch in diameter, in a well with a screen on the tubing, the mesh of which was altogether too small to admit a concretion of the size stated. He kindly sent the writer an assortment of specimens of various shapes and sizes from other wells in the same field as those previously described and of approximately of the same depth. Tests with the blow-pipe and specific gravity determinations show that the composition of the concretions is almost identical to that of those previously described. A number were examined for nuclei, but in most cases no definite nucleus could be found. When a nucleus is present it consists of earthy material made up mostly of clay and barite and this mass is often stained with iron ioxide which gives the center of the concentration a brownish tint.

This additional information is interesting from the standpoint of its bearing on the origin of concretions. It would appear to be practically impossible for bacteria or other low types of life, which are believed to play an important part in the origin of oölites, to exist in a liquid with such strong antiseptic properties as those of warm petroleum containing considerable sulphuric acid. It would seem to demonstrate that living organisms are not essenial to the development of oölites and that these may form where precipitation is taking place in an agitated solution, in the absence of life.

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[1] Oölitic and Pisolitic Barite from the Saratoga Oil Field, Texas,'' by E. S. Moore, *Bull. of the Geol. Soc. of Amer.*, Vol. 25, pp. 77–79, 1914.

SCIENTIFIC BOOKS

Ocean Magnetic Observations, 1905–1916, and Reports on Special Researches. By L. A. Bauer, Director, with the collaboration of W. J. Peters, J. A. Fleming, J. P. Ault and W. F. G. Swann. Washington, D. C., 1917. Carnegie Institution. Pp. vii + 447.

This large and handsome volume is the third of the series issued by the department of terrestrial magnetism of the Carnegie Institution and contains full reports of all the magnetic work of the department at sea during the past eleven years. The two preceding volumes deal with the observations on land for the periods 1905–1910 and 1910–1913 respectively.

In 1905 the wooden brigantine *Galilee* was chartered at San Francisco and fitted up for magnetic observations with the purpose of making a preliminary survey of the Pacific Ocean which was at that time "nearly a blank as regards magnetic observations." In the course of three years, this vessel cruised 63,834 nautical miles and, magnetically speaking, put the Pacific Ocean "on the map." In addition to the great number of valuable and accurate observations which were accumulated, these cruises of the *Galilee* afforded an opportunity for testing and improving magnetic instru-

ments adapted to sea-conditions, for establishing a practicable and suitable routine of observing and of checking instruments and in general for learning how to make magnetic observations at sea far more accurately and systematically than had ever before been attempted.

The "magnetic constants" of this wooden sailing vessel were smaller than those of any vessel which had been previously used for magnetic observations; but, small as they were, they necessitated many corrections and frequent "swinging the ship" to obtain the accuracy which Dr. Bauer had determined upon as the goal to be attained. This not only consumed much time, but also diminished the precision of the final results. Accordingly, the non-magnetic yacht *Carnegie* was built in 1909 in which the use of iron was almost wholly avoided; wooden pins, and bolts of copper and of Tobin bronze took the place of iron nails, the producer gas engine used for auxiliary power was constructed of bronze, and the only magnetic materials used were the steel valves, piston rings and cam-rollers. Repeated tests have shown that this unique vessel has no appreciable effect upon the instruments; and in her various cruises aggregating more than 160,000 miles, observations have been obtained with comparative ease and rapidity whose accuracy is far beyond anything which had previously been possible at sea.

The first 154 pages of the present volume give an account of the work done on the *Galilee*, while the remainder deals in the same way with the observations made on the *Carnegie*. The various instruments are fully described and illustrated, and it is most interesting to follow their gradual improvement and perfection. To the experimental physicist this is one of the most attractive portions of the report; especial mention may be made of the beautiful and ingenious marine earth-inductor described on pp. 196 et seq. A full account is given of the methods of making observations, their reduction and correction and of the system of checks and controls between the various instruments, as well as those introduced by shore observations which were made at every opportunity. The final results for each cruise are given in tabular form and no detail is omitted which might add to their usefulness.

In addition to the magnetic measurements, systematic observations were also carried out on atmospheric electricity, ionization and radio-activity; these form the subjects of the special reports with which the volume closes.

The practical utility of this great series of magnetic observations in correcting mariners' charts of magnetic variation is obvious; serious errors in the present charts have been found and their correction lessens the dangers of navigation in times of storm and fog when astronomical observations are impossible. And quite apart from this most useful result the ultimate scientific value of such a survey continued year after year, as it will doubtless be when the war is over, is very great. The earth's magnetism is one of the great mysteries of physical and cosmical science; observations on land alone cover too small an area of the earth's surface to afford an adequate basis of knowledge of the earth's field and of the intricacies of its secular variations. Continued, systematic sea observations of the accuracy of those recorded in this report form a necessary stage in the solution of the great problem; when that is obtained it will doubtless lead to a further knowledge of the sun's magnetism and may well have results of the highest significance in cosmical theory.

This volume is a monument to the well-directed enthusiasm and foresight of Dr. Bauer and to the skill and zeal of his associates. In this case as in many others the Carnegie Institution deserves the thanks of the scientific world for generously supporting and wisely forwarding work which could scarcely have been done at present by any other agency.

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THE RELATION OF THE MALPIGHIAN TUBULES OF THE HIND INTESTINE IN THE HONEYBEE LARVA

It has been known for nearly a hundred years that the mid-intestine of larvæ of bees

and wasps was essentially a blind sac.[1] The subsequent establishment of communication between the mid and hind-intestine in the larvæ of various members of the Hymenoptera was long since noted and has been studied in detail by Rengel.[2] The relation of the Malpighian tubules to the hind-intestine in the Hymenoptera has, on the other hand, been strangely neglected, being mentioned only incidentally or completely ignored. For example, both Anglas[3] and Rengel merely state that in the late larva or semipupa of the honeybee the Malpighian tubules open into the hind-intestine, and ignore the earlier stages. Karawaiew[4] and Perez[5] describe the Malpighian tubules in the ant larva as opening into the hind-intestine. This condition, however, does not obtain in case of the feeding larva of the honeybee, the central (caudal) ends of the tubules being blind from the time of hatching up to the sealing of the cell. The relation of the tubules to the hind- and mid-intestine during the feeding period is briefly as follows: The posterior end or fundus of the mid-intestine is, as already stated, completely closed, the epithelium being continuous here. The cephalic end of the hind-intestine is enlarged and the mouth of this enlargement closed by a thin diaphragm-like layer of cells continuous marginally with the wall of the hind-intestine The central part of this diaphragm-like structure is closely applied to the external surface of the fundus of the mid-intestine which is here devoid of a muscular coat. The pointed central blind ends of the four Malpighian tubules are inserted between these two layers, two on each side, but their tips do not extend quite to the center of the area of attachment of the mid- and hind-intestines.

In the newly hatched larva the Malpighian tubules are slender tubes, and pursue a winding course from their point of attachment up to the second or third thoracic segment, lying between the capacious mid-intestine and the body wall. Their lumen is minute, the walls being relatively very thick and composed of cells whose depth and breadth are approximately equal. In the mature larva on the other hand the Malpighian tubules are relatively voluminous, attaining, near their posterior ends, a diameter greater than that of the hind-intestine. The posterior or central ends themselves, however, always remain of small diameter. Sections through the tubules at this stage show that the walls are extremely thin and composed of flat cells. In fact, the tubules might well be described as "thin-walled tubular sacs." Evidences of distension by internal pressure are obvious.

After the larva has been sealed up in its cell by a waxen capping both the fundus of the mid-intestine and the diaphragm-like epithelium closing the cephalic end of the mid-intestine become perforated, thus establishing an avenue of communication between the mid- and hind-intestine through which the fæcal accumulations of the mid-intestine are expelled. At the same time that this occurs each of the Malpighian tubules establishes connection with the hind-intestine by means of a fine canal which perforates the diaphragm-like layer of cells which formerly closed the anterior end of the hind-intestine but which now forms an annular structure uniting the mid- and hind-intestines. Sections through the tubules show that they have greatly diminished in calibre, the walls being more or less collapsed and their component cells being correspondingly narrower and deeper.

The history of the Malpighian tubules and that of the mid-intestine during the feeding period of larval life are therefore parallel in that both, in addition to performing their

1 Dutrochet, R. J. H., "Mémoire sur les métamorphoses du canal alimentaire chez les Insectes," *Jour. de Phys.*, LXXXVI., 1818.

2 Rengel, C., "Uber den Zusammenhang von Mitteldarm und Enddarm bei den Larven der aculeaten Hymenopteren," *Zeit. wiss. Zool.*, LXXV., 1902.

3 Anglas, M. J., "Observations sur les métamorphoses internes de la Guepe et de l'Abeille," *Bull. Sci. France et Belg.*, XXXIV., 1901.

4 Karawaiew, W., "Die nachembryonale Entwicklung von *Lasius flavus*," *Zeit. wiss. Zool.*, LXIV., 1898.

5 Perez, Ch., "Contribution a l'étude des métamorphoses," *Bull. Sci. France et Belg.*, XXXVII., 1903.

original functions, retain and store up the accumulated excreta which is discharged only after feeding ceases, when such discharge on the interior of the cell occupied by the larva would not involve contamination of the food.

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SPECIAL ARTICLES

CONCERNING THE EFFECT OF INGESTED PLACENTA ON THE GROWTH-PROMOTING PROPERTIES OF HUMAN MILK

IT has been shown that the feeding of desiccated placenta to women during the first eleven days after parturition causes an increase in the protein and lactose per cent. of the milk.[1]

The present report is concerned with the growth of the infants subsisting upon the milk from the above sources. As a basis for comparison there is used the growth of the infants whose nourishment was derived from the women whose milk production was not subjected to the influence of ingested desiccated placenta.

In the tables at the end of this paper the number assigned to the infant corresponds to the number given to the mother in the previous reports.[1] It should be remembered that all the mothers were receiving the same diet and that to the second set 0.6 gm. of desiccated placenta was fed three times a day throughout the period.

Certain definite differences in the progress of growth of the two sets of infants are to be observed.

The variation limit per cent. from day to day, and the absolute per cent. variation from day to day is less in degree and tends to take on more of a positive character in those infants whose mothers were fed the desiccated placenta. Also the per cent. variation from the first day, both as regards its limits and its average is at all times less in degree. The general trend of these latter values is towards zero; this is not to be seen with the infants receiving milk from uninfluenced sources.

[1] Hammett, F. S., and L. G. McNeile, *Jour. Biol. Chem.*, 1917, XXX.; Hammett, F. S., *Jour. Biol. Chem.*, 1917, XXIX., 381.

It is evident that the recovery from the postnatal decline in weight is hastened by the consumption of milk produced under the influence of maternally ingested placenta.

It is obviously possible to eliminate from consideration the increase in protein and sugar production induced by the placental feeding as the cause of the early weight increase.

TABLE I

The Weights during the First Eleven Days after Birth of the Infants receiving Milk from the Mothers whose Production was Uninfluenced by the Ingestion of Desiccated Placenta

Infant No...	1, Oz.	2, Oz.	3, Oz.	4, Oz.	5, Oz.	6, Oz.	7, Oz.	8, Oz.
Day 1......	118	148	120	120	119	104	96	144
2......	108	138	116	111	114	98	91	143
3......	107	130	114	107	112	100	94	131
4......	109	129	109	110	106	102	94	135
5......	106	129	112	111	105	104	100	134
6......	105	132	114	104	106	104	96	134
7......	108	131	112	104	108	104	98	141
8......	108	130	108	102	107	107	91	143
9......	105	129	109	105	108	104	91	149
10......	108	128	108	112	103	107	93	146
11......	108	129	108	114	104	107	96	148

TABLE II

The Weights during the First Eleven Days after Birth of the Infants receiving Milk from the Mothers whose Production was Influenced by the Ingestion of Desiccated Placenta

Infant No...	1, Oz.	2, Oz.	3, Oz.	4, Oz.	5, Oz.	6, Oz.	7, Oz.	8, Oz.
Day 1......	150	119	111	135	144	76	114	123
2......	138	115	108	123	142	72	112	117
3......	133	112	101	123	136	71	107	121
4......	134	112	100	123	136	72	108	122
5......	140	113	99	124	138	72	110	119
6......	140	114	100	123	143	72	106	126
7......	142	115	100	124	146	73	104	126
8......	145	118	102	124	147	76	106	124
9......	149	118	101	124	144	76	108	118
10......	153	116	99	128	144	75	106	126
11......	150	116	98	130	143	75	108	126

These results may then be best interpreted on the assumption of the presence of some growth-promoting factor in the ingested placenta, which has been passed on to the infants in the milk. There is thus opened up the probability of the placenta taking some part in

intra-uterine growth aside from its function as a transfer system.

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THE EFFECT OF DRAINAGE ON SOIL ACIDITY

FOR the purpose of studying the effect of drainage on soil acidity, samples of soil were taken in October, 1916, from three of the experiment fields of the Purdue Agricultural Experiment Station. These fields are located near Westport, North Vernon and Worthington. The soils of these fields are all heavy silt loam, very low in organic matter and naturally poorly drained and quite acid in reaction. All of these fields have been thoroughly tile drained from three to five years. A portion of the Westport field is undrained and there are adjacent undrained, untreated areas alongside the North Vernon and the Worthington fields.

TABLE I

RELATIVE ACIDITY OF DRAINED AND UNDRAINED SOILS

Field and Soil Treatment	Lbs. $CaCO_3$ Needed per 2,000,000 Lbs. Soil	
	Drained	Undrained
Westport field:		
Limestone	40 #	760 #
Limestone, phosphate and potash	30 #	360 #
Untreated	860 #	1,280 #
North Vernon field:		
Untreated	1,880 #	2,840 #
Worthington field:		
Untreated	740 #	1,600 #

Table I. shows the acidity of the soil as determined by the potassium nitrate method. Without entering into a discussion of the comerits of different soil acidity methods, it may be said that on these soils, which are low in organic matter, there is no great difference in the degree of acidity shown by this method and the lime water and calcium salt methods. These results are consistent enough to indicate that drainage has a material influence on the acidity of soil of this type.

Farmers often refer to wet, poorly drained land as sour. While agricultural writers have placed little or no emphasis on such a correlation, it is quite probable that soils in general will tend to become less acid when thoroughly drained, and vice versa; they will tend to become more acid when water-logged and poorly aerated. In testing soil acidity at different seasons of the year the results often vary quite a little in samples from the same plots of soil. These differences can not be attributed altogether to errors in sampling. The writer believes that at least part of the change of acidity is due to difference in aeration and moisture content of the soil at different seasons. Lipman and Waynick,[1] in an investigation of the effect of climate on soil properties, report that Maryland soil, which shows an acid reaction in its original location, when transported to Kansas or to California becomes neutral or slightly alkaline. It is quite probable that the better drainage and aeration of the soil when placed under less humid conditions could account very largely for the changes in reaction.

Considering SiO_2 an acid-forming oxide, practically all soils except those very high in the basic reacting elements, have a potentially great capacity for developing an acid reaction.

The writer believes that the constitution of the silicates of aluminum has more to do with injurious soil acidity than any other single factor. The acidity of aluminum silicates varies both with the relative proportion of SiO_2 to Al_2O_3 and with the amount of combined water in the silicate.[2] The weathering and changing of soil silicates under poorly drained or well-drained conditions would undoubtedly vary the constitution of the silicates and also vary the degree of soil acidity. It is quite true that certain types of well-drained sandy soils are acid. It is true also that a number of other factors besides drainage conditions affect soil acidity, but it is probable that the most acid soils are formed in poorly drained areas.

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[1] Lipman, C. B., and Waynick, D. D., *Soil Science*, Vol. I., No. 1, p. 5, 1916.

[2] Conner, S. D., "Acid Soils and the Effect of Acid Phosphate and Other Fertilizers upon Them," *Jour. Ind. and Eng. Chem.*, Vol. VII., No. 1, p. 35, 1916.